EXECUTIVE SUMMARY

CONTROLS FOR FINE PARTICLE EMISSIONS
FROM INDUSTRIAL SOURCES IN CALIFORNIA

by

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INTRODUCTION

The purpose of this study is to provide information on the degree of fine particle control feasible for stationary sources in California and estimate the costs for several devices of fine particle emission control. The cost estimates include capital and annual operating expense. This information is intended as a reference for CARB officials and other state officials in considering the impact that an emission standard for fine particles would have on industry in California. Fine particles have been defined for these studies as those with an aerodynamic diameter less than 3 μmA. They are a major air pollution problem because they reduce visibility, can be deposited in the lungs, and they are difficult to collect in conventional control devices.

The California Air Resources Board has sponsored previous studies to survey stationary industrial pollution sources and identify the pollutants and control devices used. A study done by Acurex Corporation (Minicucci et al. 1980) summarizes stationary air pollution sources in California and the control technologies used for these sources. The report for that study lists specific processes in eight industrial categories and the major air pollutants emitted from each process. Control methods are listed for each process as well as an estimate of the control efficiency of the device and cost information.

As part of that study, Acurex developed a data base and associated software to allow CARB to organize, access, and update the information. The information compiled by A.P.T. in the present study will be entered into this data base.

The CARB also contracted with KVB, Inc. to identify major sources of fine particles in The South Coast Air Basic (SCAB) and characterize the emissions from these sources. KVB (Taback et al., 1979) reported field test data for over twenty different sources. The information reported includes particle size distributions, chemical analysis of the particles, and characteristics of the gas stream, such as temperature and flow rate.

In the present study, the emissions from the major sources were characterized to determine the most applicable control devices and to estimate the fine particle control efficiency.

METHODOLOGY

This study was divided into three distinct tasks. The first task was to determine the stationary sources of fine particle emissions in California and characterize the emissions from these sources. The second task was to determine the control technologies available for fine particles. The third task was to estimate the efficiency of the control devices on the sources and the costs associated with the control devices.

Seven industrial categories were specified by the CARB for inclusion in this study:

1. Combustion of fuels
2. Food and agricultural operations
3. Metallurgical operations
4. Mineral operations
5. Solvent use
6. Incineration
7. Wood milling

The sources to be evaluated in each category were not specified, except for the fuel combustion category. In this case, the CARB specified that the following sources be evaluated:

1. Residual oil-fired utility boilers
2. Coal-fired utility boilers
3. Residual oil-fired industrial boilers
4. Distillate oil-fired industrial boilers
5. Crude oil-fired industrial boilers.

For the other six categories the sources of particle emissions were determined from Emission Inventory System (EIS) data supplied by the CARB. The EIS data are a compilation of data reported to the California Air Resources Board from all the Air Pollution Control Districts (APCDs) in the state. The EIS lists the companies which are major sources of air pollution in each APCD. Specific processes are listed under each company and the amount of pollutants emitted by that process are listed. The amount of particulate emissions are reported in tons per year. A list was compiled of specific industries and the operations within each industry which are the largest sources of particle emissions in the state.

Computer literature searches were performed to locate information on the sources of particle emissions. In particular, it was necessary to obtain particle size distributions to determine which sources emit fine particles.

Contacts were made with people in various departments of the Environmental Protection Agency (EPA) to obtain information not yet published or which did not appear in the literature search. Officials of several APCDs were contacted as well as researchers at other companies.

Data from the Fine Particle Emission Inventory System (FPEIS) maintained by the EPA were used to characterize emissions from several sources. The FPEIS data are reported by organizations which have conducted source tests, generally under contract with the EPA. The FPEIS contains information on the source, the test conditions, particle size distributions, and mass concentrations.

For each of the sources identified as a major source of fine particles, a source description has been written. Information defining the gas flow and particle characteristics of each source is included in the descriptions.

Conventional and developing fine particle control technologies in 4 major categories - wet scrubbers, electrostatic precipitators, fabric filters, and cyclone separators are identified through literature survey and correspondence with individuals. A description of the device, its operating principle and its design information have been written for each control device.

RESULTS

Table 1 presents a summary of the emissions from the major sources of fine particle emissions in California, the types of control devices presently used on the different sources, and the fine particle control devices that were evaluated in this study.

Particle collection systems can be designed to achieve almost any collection efficiency, at a cost which increases with efficiency. At present, there are no emission standards for fine particles. In order to explore the possibilities, CARB specified that the costs for 50, 75, and 90% collection of particles less than 3μmA were to be estimated. Of the ten fine particle control devices selected for evaluations, Venturi, ESP, flux-force/condensation, precharged ESP, and Calvert Collision Scrubber have proven mathematical models or empirical equations. Calculations with these devices were done only for the above three levels of efficiency, not to determine the maximum feasible collection efficiency of these devices on a source.

For the remaining five control devices (i.e. fabric filter, electrified filter, pulse charged ESP. charged spray scrubber, and the Spray Charging and Trapping (SCAT) scrubber), reliable design equations are not available. Calculations for conditions to achieve the three levels of efficiency cannot be done. Therefore, calculations were based on field test results and the reported efficiency shows what the control device could do under the same conditions as the field tests.

For a given efficiency, one calculates the dimensions and operating conditions of a control device on a source. Cost estimations were then made for a typical plant for this source. Capital cost, operating cost, and annualized operating cost were accounted for in the calculations.

Calculation results were reported in the CARB data base format.

TABLE 1. MAJOR INDUSTRIAL SOURCES OF FINE PARTICLES IN CALIFORNIA

Process	Uncontrolled Emissions (Tons/Yr)	Weight,% $\leq 3\ \mu mA$	Control Technology: Present	Control Technology: Fine Particle
FUEL COMBUSTION				
Oil-Fired Boilers				V, ES, CS, E, EH, EP, B, EF
Residual Oil Field-Erected Boilers		70 - 95	E	
Package Boilers		45 - 70	P	
Crude Oil Package Boilers		30 - 70	S	
Distillate Oil Package Boilers		75 - 95	E	
Coal-Fired Boilers				V, ES, CS, E, EH, EP, B, EF
Field-Erected Boilers		40	P, C, E, S, B	

B = Baghouse (fabric filter)
C = Cyclone separator
CO = Confinement
CS = Calvert Collision Scrubber™
E = Electrostatic Precipitator (ESP)
EF = Electrostatically Augmented Filter
EH = ESP with SoRI precharger
EP = Pulse charging ESP
ES = Charged spray scrubber
F/C = Flux force/condensation scrubber
GB = Granular bed filter
P = Process modification
S = Scrubber
SCAT = Spray charging and trapping scrubber
V = Venturi scrubber

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Process	Uncontrolled Emissions (Tons/Yr)	Weight % $\leq 3\ \mu mA$	Control Technology Present	Control Technology Fine Particle
FOOD AND AGRICULTURE				
Rice Drying	1,400	10 - 40	C	V, CS, B
Grain Drying	300	10 - 15	B	V, CS, B
Alfalfa Drying	600		C, S	
Primary Cooling		12		
Secondary Cooling				
Air Meal Separato		42		
Grain Grinding and Milling	310		C	B
Cotton Ginning	490			V, CS, B
Incliner Cleaner			C	
Unloading and Dryer			S	
Unloading Separator				
Mote Cleaner				
Lint Cleaner				
Battery Condenser		5	S	
METALLURGICAL				
Coke Ovens			P	V,F/C,ES SCAT,CS,E B,EF
Charging	140	<20		
Pushing-Clean	1,100	6		
Pushing-Green				
Primary Iron and Steel				V,F/C,ES,E CS,B,EF
Sintering Windbox	270	<5	S,E,B,C	
Blast Furnace Cast House	690	60	B	
Open Hearth Furnace with Oxygen Lancing	720	90	B,S,E	
Basic Oxygen Furnace				
Charging Clean Scrap		45	B,S,E	
Charging Oily Scrap		65		
Scarfing Machine	70			

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Process	Uncontrolled Emissions (Tons/Yr)	Weight % $\leq$ 3 µmA	Control Technology Present	Control Technology Fine Particle
METALLURGICAL				
Steel Foundry			B	V,F/C,ES,B CS,E,EF
Electric Arc Furnace				
No Oxygen Lancing	150	35		
with Oxygen Lancing				
Brass	110			V,F/C,ES,E CS,B,EF
Rotary Furnace		95	B	
Reverberatory Furnace				
Lead	100			V,F/C,ES,E CS,B,EF
Reverberatory Furnace		80	B	
Secondary Zinc	70			V,F/C,ES,E CS,B,E
Reverberatory Furnace		90	B	
MINERALS				
Cement				V,ES,CS,E EH,EP,B,EF
Dry Kiln	1,600	4	C,B,E	
Wet Kiln	520	4 - 30	C,B,E	
Dryer/Grinder	410		B	
Clinker Cooler	260	1.5-3	C,B	
Asphalt				V,ES,CS,E,B EH,EP,EF
Road Mix				
Agregate Dryer	1,800	1 - 8	C,S	
Lime Manufacture				V,ES,CS,E,B EH,EP,EF
Rotary Calcining Kiln	230	30-80	S	
Gypsum				V,ES,CS,E,B EH,EP,EF
Gypsum Calciner	140	50		

TABLE 1. MAJOR INDUSTRIAL SOURCES OF FINE PARTICLES IN CALIFORNIA

Process	Uncontrolled Emissions (Tons/Yr)	Weight % < 3 µmA	Control Technology Present	Control Technology Fine Particle
MINERALS				
Asbestos Milling				V,ES,CS,E,B EH,EP,EF
Glass Manufacture				V,F/C,ES,CS EH,EP,B,EF
Melting Furnace		>80		
Rock,Sand, and Gravel				V,ES,CS,E,B EH,EP,EF
Primary Crushing	5,100		CO,S,B	
Screening/Handling	780		CO	
Secondary Crushing	500		CO,S,B	
Aggregate/Sand Drying	470			
Fines Milling	110			
Abrasive Blasting	70		S,B,C	
SURFACE COATING	720	60-65	S	V,ES,CS
Auto Manufacturing				
Can Manufacturing				
Metal and Wood Manufacturing				
INCINERATION				
Municipal Incineration		30-40	E,S,B	V,F/C,ES,CS E,B,EF
Industrial Incineration				V,F/C,ES,CS E,B,EF
Wood Waste Boiler		96		
WOOD MILLING AND WORKING			C	V,ES,CS,E,B
Wood Sander		47		
Wood Saw		7		

CONCLUSIONS

Control technologies are currently available at reasonable costs, for removing the fine particle emissions from all the sources considered in this study to meet the criteria set by CARB. However, these criteria (i.e. 50, 75, and 90% removal of fine particles) are not good evaluation standards because even with 90% removal of fine particles, the emissions from some sources would still violate the present mass emission regulations. A better criterion would be a maximum mass emission concentration for fine particles. The information obtained in this study is sufficient for one to determine the attainable efficiency and cost of a control device on any source.

RECOMMENDATIONS

This study was limited to the use of existing knowledge of control technology, emission and source characteristics, and design methods. No experimental work was done to evaluate the accuracy of the information available in the literature, such as particle size distribution and concentration of emissions from a source. To accurately evaluate the effectiveness and cost of control for fine particles, the following are recommended.

1. Because of many adverse effects of fine particles, a separate regulation on fine particle emissions is needed. An evaluation of fine particle control technologies in terms of this regulation would be more appropriate and should be done.

2. Source sampling should be done to determine emission characteristics and control efficiency for the following operations:
   a. Food and agriculture processing
   b. Gypsum calcining
   c. Asbestos milling
   d. Industrial incineration
   e. Wood milling and working.

3. Pilot scale tests of developing technologies on actual sources should be made to provide more reliable performance information. The following systems need further evaluation:
   a. Charged particle/charged spray scrubber
   b. Electrostatically augmented filter
   c. Electrostatically augmented granular bed filter
   d. Electro-cyclone
   e. Pulse charging ESP and ESP with SoRI precharger (on sources other than coal-fired boilers).

REFERENCES

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